CHAPTER 7: CONSTRUCTED WETLANDS

DEFINITION

Constructed wetlands are engineered systems designed to simulate the water quality improvement functions of natural wetlands to treat and contain surface water runoff pollutants and decrease loadings to surface waters. Constructed urban runoff wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not replicate all of the ecological functions of natural wetlands (United States Environmental Protection Agency, 1993).

EFFECTIVENESS

Constructed wetlands are effective for removing a wide range of pollutants from urban runoff. The United States Environmental Protection Agency (1993) lists the following percent removals for constructed wetlands:

Pollutant	TSS	TP	TN	COD	Pb	Zn	Factors
Average	65	25	20	50	65	35	Storage volume
Reported Range	(-20)-100	(-120)-100	(-15)-40	20-80	30-95	(-30)-80	Deten. time
Probable Range	50-90	(-5)-80	0-40	---	30-95	___	Pool shape
No. Values	23	24	8	2	10	8	Biota season

Constructed wetlands remove pollutants through several mechanisms. The incoming runoff is slowed as it enters the wetland, allowing the settling of the suspended solids. Phosphorus and trace metals are frequently attached to particulate matter and are thus removed by sedimentation of these particles.

Constructed wetlands provide many sites for the adsorption of pollutants including the suspended sediments, plant matter, and bottom sediments and organic matter. The bottom sediments and organic matter can become a sink for pollutants as they build up over time. The sediments and organic mat are the only place available for long term storage of pollutants.

As the water flows through and around the vegetation some of the pollutants will be physically filtered out of the water. This filtration is not very effective in removing most pollutants from urban runoff except the larger floatables.

The surfaces on the various features in the wetland provide sites for micro-organisms to grow. These micro-organisms are effective in removing pollutants from the water. Kadlec (1994) has demonstrated that pollutant reductions are proportional to surface area not volume. The larger the surface area of the wetland the more plants and bottom area and corresponding increase in surfaces available for micro-organisms. This process is important in the removal of oxygen demanding substances and in the removal of nitrogen through nitrification/denitrification (Schueler, 1992). The principle function of vegetation in wetlands systems is to create additional environments for microbial populations (United States Environmental Protection Agency, Hammer, 1993).

The uptake by plants can be an important source of pollutant removal. The storage of pollutants in the live plants is only temporary however, a portion of the pollutants will be retained in the plants when they die and added to the organic matter on the wetland bottom. Thus a portion of the plant organic matter can be a source of long term storage of pollutants. The primary mechanism for long term removal of phosphorus is through plant cycling and soil accretion (Kadlec, 1994)

PLANNING CONSIDERATIONS

Constructed wetlands are complex ecosystems and require careful planning if they are to function correctly. The first consideration is the amount of available land area at the lower end of the watershed. Constructed wetlands should not be designed solely on surface area; for planning purposes 2% to 3% of the watershed area may be needed for the constructed wetland.

After determining the availability of sufficient land area, the availability of sufficient water is the most critical item. Because of the nature of the watersheds these wetlands will be serving, the water availability will be variable and not completely reliable. The urban area above the constructed wetland will be subject to all the factors discussed in chapter 2, particularly the high peak flows and low base flows. Wetland construction efforts often fail when a plan fails to provide hydrologic support of the proposed structure and functions. Plans should include calculations indicating the amount of water required to support the planned wetland plant community. These calculations should indicate the major input and output components of a hydrologic budget (Pierce, 1993).

Wetlands can provide stormwater detention and reductions in peak flow. The ability of the downstream water body to accept increases in runoff and the impact of the development must be evaluated. If the wetland will provide for stormwater detention, the stormwater storage must be in addition to the normal water quality volume provided in the wetland. The water depth and duration of inundation above the normal water quality volume are critical factors in selecting vegetation.

Finally, planning must consider the other functions of the wetland. Will it be an amenity to the site providing wildlife, recreational, and other benefits? The types of vegetation and water regimes need to be planned in advanced.

Schueler (1992) breaks constructed wetlands into several categories, four of which are of interest:

Design 1: Shallow Marsh System. The Shallow marsh design has a large surface area, and requires a reliable source of baseflow or groundwater supply to maintain the desired water elevations to support emergent wetland plants. Consequently, the shallow marsh system requires a lot of space and a sizeable contributing watershed area to support the shallow permanent pool.

Design 2: Pond/Wetland System. The pond/wetland design utilizes two separate cells for stormwater treatment. The first cell is a wet pond and the second cell is a shallow marsh. The multiple functions of the wetpond are to trap sediments, reduce incoming runoff velocity, and to remove pollutants. The pond/wetland system consumes less space than the shallow marsh, because the bulk of the treatment is provided by the deeper pool rather than the shallow marsh.

Design 3: Extended Detention Wetland. In extended detention wetlands, extra storage is created above the shallow marsh by temporary detention of runoff. The extended detention feature enables the wetland to consume less space, as temporary vertical storage is partially substituted for shallow marsh storage. A new growing zone is created along the gentle side-slopes of extended detention wetlands that extends from the normal pool elevation to the maximum extended detention water surface elevation.

Design 4: Pocket Wetlands. Pocket wetlands are adapted to serve smaller sites from one to ten acres in size. Because of their small drainage areas, pocket wetlands usually do not have a reliable source of baseflow, and therefore exhibit widely fluctuating water levels. In most cases, water levels in the wetland are supported by excavating down to the water table. In drier areas, the pocket wetland is supported only by stormwater runoff, and during extended periods of dry weather, will not have a shallow pool at all (only saturated soils). Due to their small size and fluctuating water levels, pocket wetlands often have low plant diversity and poor wildlife habitat value.

DESIGN CRITERIA

The design of wetlands for treating urban runoff is a new field without a lot of generally accepted design standards. The following standards are minimum standards, and are intended to give direction without being too restrictive as new technology is developed. It should also be understood that these standards are not all inclusive regarding the design of constructed wetlands, but are intended to address those areas unique to urban runoff. The designer must have a general knowledge of wetlands creation including soils, hydrology, and vegetation.

The volume of storage capacity below the outlet (water quality volume) should be equal to a one inch of rainfall over the tributary area.

Surface area of the wetland should be a minimum of 2% to 3% of the watershed area.

The wetland should have two micropools comprising between 20% and 40% of the total wetland water quality volume.

The first micropool to be a sediment forebay and contain 10% of the total wetland water quality volume.

The second micropool to be an afterbay and contain 10% to 30% of the total wetland water quality volume.

The micropools should be a minimum of 3 feet and a maximum of 6 feet deep

The wetland between the two micropools should be a marsh with variable depth between 6 inches and 2 feet deep.

The outlet of the sediment forebay to the marsh should be designed to evenly distribute the flow over the marsh.

The length of the basin should be at least twice the width.

Inlets and outlets should be at opposite ends of the wetland, if this can not be accommodated, then baffle islands should be constructed to maximize the flow path.

A hydrologic budget should be prepared for the design demonstrating that sufficient water is available to maintain the wetland, and that the wetland will not be inundated with an excess of water.

The marsh portion of the wetland should be designed with a dense, well distributed stand of vegetation such as cattails or bulrushes.

If the wetland is also utilized for stormwater detention, it should be designed based upon extended detention.

Maximum sideslopes should be 2:1. provision must be made for access by maintenance equipment.

The constructed wetlands should have a freeboard of at least one foot.

The outlet should be a reverse slope pipe or other device which will allow water from below the surface to outlet, thus trapping floatable solids.

Outlet should be installed with suitable anti-seep collars.

Inlet area should be protected from erosion with suitable riprap or the inlet enter the pool below the water surface.

A buffer of dense vegetation or fencing should be provided to limit access

Wetland berms may be classified as a dam and require approval by the Water Resources Division of DES

Figure 7.1: Schematic of a Constructed Wetland